

## PATENT ABSTRACTS OF JAPAN

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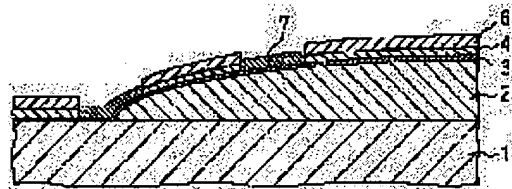
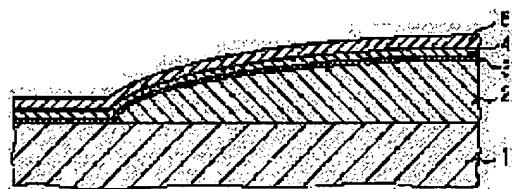
(72)Inventor : TSUJINO FUMI

## (54) PRODUCTION OF THIN-FILM MAGNETIC HEAD

## (57)Abstract:

**PROBLEM TO BE SOLVED:** To form a magnetic core which has a prescribed track width and has a good track profile by applying a photoresist on an antireflection film at the time of forming a mask for the core.

**SOLUTION:** After respective material layers 2 are formed on a substrate, the upper magnetic core is formed. At this time, a plating ground surface film 3 is formed and the antireflection film 4 is formed on this film 3. The photoresist is applied on the film 4 to form a resist film 5. A frame-shaped photomask corresponding to external shape of the upper magnetic core is superposed on the film 5 and is exposed to a prescribed wavelength light. The light past the film 5 is absorbed by the film 4 to prevent the reflection thereof. If development is executed after the exposure of the film 5, the mask 6 for the frame-shaped core corresponding to the external shape of the upper magnetic core is formed with high dimensional accuracy. Next, the substrate is subjected to an etching treatment over the entire part to remove the film 4 of the region not formed with the mask 6, and a magnetic film 7 is precipitated on the exposed ground surface film 3 and, thereafter, the mask 6 and the remaining film 4 are peeled.



## LEGAL STATUS

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[Date of registration]

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**CLAIMS**

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[Claim(s)]

[Claim 1] A manufacture method of the thin film magnetic head characterized by forming an antireflection film on the above-mentioned magnetic film, and applying a photoresist on this antireflection film before facing forming a mask for cores of a predetermined core pattern by exposing this photoresist and applying a photoresist on a magnetic film, after applying a photoresist.

[Claim 2] A manufacture method of the thin film magnetic head characterized by forming an antireflection film on the above-mentioned plating substrate film, and applying a photoresist on this antireflection film before facing forming a mask for cores of the shape of a frame corresponding to an appearance configuration of a magnetic core by exposing this photoresist and applying a photoresist on a plating substrate film, after applying a photoresist.

[Claim 3] A manufacture method of the thin film magnetic head according to claim 1 characterized by being the compound-die thin film magnetic head which the thin film magnetic head manufactured turns into from the magneto-resistive effect mold thin film magnetic head and the magnetic-induction mold thin film magnetic head.

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## DETAILED DESCRIPTION

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### [Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention -- a magnetic core and a conductor -- a coil is related with the manufacture method of the thin film magnetic head formed of a thin film process.

[0002]

[Description of the Prior Art] For example, as the record reproducing head of a hard disk drive (driving gear), the thin film magnetic head (an inductive head is called hereafter.) of the magnetic-induction mold which uses a magnetic metal thin film as a magnetic core is used.

[0003] as shown in drawing 11 (a) and (b), the lower magnetic core 22 and the gap film 23 form this inductive head on a substrate 21 -- having -- a this top -- a spiral-like conductor -- the coil layer 24 and the up magnetic core 25 carry out a laminating one by one through an insulating layer 26 in between -- having -- further -- the up magnetic-core 25 top -- a wrap -- it needs -- a protective coat 45 is formed and constituted. In this inductive head, magnetic gap g is formed in a record medium and the field (magnetic-recording data-medium sliding surface) S which counters with the gap film 23 formed between the lower magnetic core 22 and the up magnetic core 25.

[0004] The record signal recorded on a hard disk is short-wavelength-sized increasingly, and it is becoming impossible however, to be unable to respond from the above-mentioned inductive head of the playback sensitivity to a short wavelength signal being inadequate.

[0005] For this reason, recently, the compound-die arm head using the magneto-resistive effect mold arm head (an MR head is called hereafter.) which was excellent in short wavelength sensitivity as an arm head for signal regeneration tends to be adopted, using an inductive head as an arm head for record.

[0006] This MR head is the reproducing head which used the magneto-resistive effect phenomenon in which an electric resistance value changed, according to the angle which the sense of the magnetization looked at by transition metals and the sense of the current which flows that interior make.

[0007] That is, when MR magnetic thin film receives the magnetic leakage flux from magnetic-recording data medium, the sense of magnetization of the above-mentioned MR magnetic thin film rotates by the magnetic flux, and it comes to have an angle according to a magnetic amount to the sense of the current which flows inside the MR magnetic thin film concerned. So, the electric resistance value of MR magnetic thin film changes, and since the voltage change according to this variation appears in the electrode of the both ends of MR magnetic thin film which is passing current, it can read a magnetic-recording signal as a voltage signal.

[0008] As shown in drawing 12 (a) and (b), the laminating of the magnetic-induction mold magnetic-head section (inductive head section) B is carried out on the magneto-resistive effect mold magnetic-head section (MR head section) A, a protective coat 46 is formed and, specifically, the compound-die thin film magnetic head equipped with this MR head and inductive head is constituted so that it may cover on the inductive head section B further.

[0009] among these, the magneto-resistive effect element (MR element) 29 to which the lower shield magnetic layer 28 is formed on a substrate 27, and, as for the MR head section A, becomes it from MR magnetic thin film on this and bias -- in between, through the insulating layer 34, the laminating of a conductor 30 and the up shield magnetic layer 31 is carried out, and they are constituted. In addition, in the both ends of the MR element 29, the laminating of the front end electrode 35 and the back end electrode 36 for energizing sense current is carried out to the MR element 29 concerned, respectively. In this MR head section A, the end face of MR element is exposed to the magnetic-recording data-medium sliding surface S, and the playback gap gA is formed of the side edge section of this end face.

[0010] on the other hand, the inductive head section B makes the up shield magnetic layer 31 of the MR head section A serve as the function of a lower magnetic core, and the gap film 37 forms it on this lower magnetic core 31 -- having -- a

this top -- a spiral-like conductor -- in between, through the insulating material layer 40, the laminating of a coil 38 and the up magnetic core 39 is carried out, and they are constituted. In this inductive head section B, the record gap gB is formed in the magnetic-recording data-medium sliding surface S with the gap film 37 formed between the lower magnetic core 31 and the up magnetic core 39.

[0011] By the way, such an inductive head and a compound-die arm head are manufactured according to the thin film process which combined the sputtering method, plating, and the photolithography method.

[0012] Among these, the lower magnetic core and up magnetic core which constitute the inductive head section of an inductive head or the compound-die magnetic head are formed with the so-called frame plating.

[0013] That is, in order to form a magnetic core with frame plating, all over the field which should form this magnetic core, a plating substrate layer is formed by the sputtering method, and a resist film is formed by applying a photoresist on this plating substrate layer. And on this resist film, the photo mask of the shape of a frame corresponding to the appearance configuration of a magnetic core is piled up, and a resist film is exposed from on this photo mask. Consequently, the photoresist of the portion which the photo mask has not piled up solubilizes and remains in the shape of [ corresponding to the configuration, i.e., the appearance configuration of a magnetic core, where only the photoresist of the portion which the photoresist piled up imitated the pattern of this photo mask ] a frame.

[0014] And after depositing a magnetic film with electrolysis plating on the above-mentioned plating substrate layer by using the resist film of the shape of this frame as the mask for cores, it is removing the unnecessary magnetic film around frame-like the mask for cores, and this mask for cores, and a magnetic core will be formed.

[0015]

[Problem(s) to be Solved by the Invention] However, a photoresist is applied on a plating substrate film in this way, and when forming the mask for cores by exposing this, deterioration of the truck profile by surroundings lump of the light which carried out incidence to exposure becomes a problem.

[0016] That is, since the plating substrate layer which consists of metallic materials, such as nickel-Fe, is formed in the resist film bottom, reflection tends to take place by the interface of this plating substrate layer and a resist film. When the light which carried out incidence to exposure reflects by this interface, a resist will expose also by the reflected light with incident light.

[0017] a case so that the mask for cores of an up magnetic core may be formed especially here -- the bottom of it -- a lower magnetic core and a conductor -- since the coil layer, the insulating material layer, etc. are formed, the level difference originating in the thickness of these each class has arisen in the interface of a plating substrate layer and a resist film. If a level difference is in the interface of a plating substrate film and a resist film, as shown in drawing 13, un-arranging [ that the dimensional accuracy of breadth and a resist film gets worse / the reflected light L reflected from the slant face in the both sides of a level difference 41 / the area of the exposed section / rather than a surroundings lump, consequently the pattern of a photo mask 42 to the photo-mask 42 down side ] will arise.

[0018] If dimensional accuracy becomes low in this way with the mask for cores, naturally the up magnetic core in which patterning was carried out by this will also become what has low dimensional accuracy.

[0019] In an up magnetic core, it is a configuration near [ which regulates width-of-recording-track WT of an arm head ] the magnetic-recording data-medium sliding surface (the truck section is called hereafter) that close dimensional accuracy is required most. That is, although the plan which looked at the up magnetic core from the bottom is shown in drawing 14, for the truck section is formed by width of face being made narrowly so that it may be set to predetermined width-of-recording-track WT near the magnetic-recording data-medium sliding-surface S in this way, and acquiring good record reproducing characteristics, in an up magnetic core, the configuration of this truck section becomes important.

[0020] Here, if drawing 11 (b) and drawing 12 (b) are seen, these show the ideal configuration of the truck section seen from the magnetic-recording data-medium sliding-surface side, and it is ideal [ the truck section of an up magnetic core ] that width of face is fixed in the thickness direction not to mention having predetermined width-of-recording-track WT in this way.

[0021] however, the truck section formed at the above-mentioned production process spreads as are shown in drawing 15, and it becomes width of face larger than predetermined width-of-recording-track WT at the whole and this width of face moreover goes to the bottom -- like -- it is a truck profile. Side fringing increases that the truck section is such a profile, and the width of recording track more effectual than actual width of face will become still larger.

[0022] Until now, to the effect [ on such a level difference slant face ] of reflective, the size shift amount of a photo mask and the width of recording track of completion is predicted experientially, and it is coped with by designing a photo mask based on it. However, it is difficult for the level difference by each material layer formed at the production process before an up magnetic core for many condition at the time of manufacture to be easy to be influenced, and to

predict this correctly. For this reason, it is very difficult to obtain the desired width of recording track by this method, and  $\pm 0.5$  micrometers of tolerance must be expected and the actual condition cannot but manufacture an arm head.

[0023] From the thin film magnetic head, narrow-ization of the width of recording track is increasingly called for for the purpose of the densification of record. However, if the dimensional accuracy of the track section of a magnetic core becomes low in this way, it will become very difficult to attain  $\pm$  width-of-recording-track-ization.

[0024] Then, this invention is proposed in view of such the conventional actual condition, and it aims at offering the manufacture method of the thin film magnetic head that it can form with close dimensional accuracy, and the mask for cores has the predetermined width of recording track, and can form the good magnetic core of a track profile by the FORI lithography method.

[0025]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, after a manufacture method of the thin film magnetic head of this invention applies a photoresist, before it faces it forming a mask for cores of a predetermined core pattern by exposing this photoresist and it applies a photoresist on a magnetic film, it forms an antireflection film on the above-mentioned magnetic film, and is characterized by applying a photoresist on this antireflection film.

[0026] Moreover, after applying a photoresist, before facing forming a mask for cores of the shape of a frame corresponding to an appearance configuration of a magnetic core by exposing this photoresist and applying a photoresist on a plating substrate film, an antireflection film is formed on the above-mentioned plating substrate film, and it is characterized by applying a photoresist on this antireflection film.

[0027] Thus, if an antireflection film is prepared in the resist film bottom, since it will be exposed without influencing a resist film of the reflected light, a mask for cores is formed with close dimensional accuracy. Therefore, reflecting this, close dimensional accuracy is obtained, the track section has predetermined width-of-recording-track WT in homogeneity in the thickness direction, and a magnetic core is also formed. Thus, since side fringing is stopped small, record is performed with the predetermined width of recording track to a record medium, and the magnetic head in which a magnetic core was formed can aim at improvement in recording density in the direction of a track.

[0028] In addition, even if the thin film magnetic head manufactured by this invention is an inductive head, it may be the compound-die thin film magnetic head which consists of a MR (magneto-resistive effect mold) arm head and inductive beef fat.

[0029]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained. In addition, the case where an inductive head is manufactured here is made into an example, and it explains.

[0030] a lower magnetic core and a gap film form the inductive head manufactured by this example on a nonmagnetic substrate -- having -- a this top -- a spiral-like conductor -- in between, through the insulating material layer, the laminating of a coil layer and the up magnetic core is carried out one by one, and they are constituted.

[0031] the nonmagnetic substrate top which consists of a sintered compact of an aluminum-Ti-C system etc. in order to manufacture such an inductive head -- a lower magnetic core, a gap film, the 1st insulating material layer, and a spiral-like conductor -- a coil layer and the 2nd insulating material layer are formed. Each [ these ] material layer is formed according to the manufacturing process of the usual inductive head according to the thin film process which combined the sputtering method, plating, the photolithography method, etc. Signs that each [ these ] material layer 2 was formed are shown in a substrate 1 at drawing 1 . Here, a total of h of the level difference produced by each [ these ] material layer was about 15 micrometers.

[0032] Thus, after forming each material layer 2, an up magnetic core is formed with frame plating.

[0033] In order to form an up magnetic core, as shown in drawing 2 , the plating substrate film 3 which consists of nickel-Fe etc. on the insulating material layer of the above 2nd is first formed by the sputtering method etc.

Subsequently, an antireflection film 4 is formed on this plating substrate film 3. This antireflection film 4 is for preventing the reflection of light which carried out incidence to exposure in the mask formation production process for cores performed at degree production process. Therefore, it is desirable to use what has a high absorption coefficient to the light for exposure as this antireflection film 4, and the material which specifically has a bigger absorption coefficient than 1.5 to the light for that exposure. In addition, as a material of this antireflection film, any of an organic material and an inorganic material are sufficient. In the case of an organic material, it is formed as a thin film of a spreading mold, and, in the case of an inorganic material, is formed as a spatter film or a vacuum evaporation film.

[0034] Then, as shown in drawing 3 , on this antireflection film 4, a photoresist is applied in 5-10-micrometer thickness, and the resist film 5 is formed. And photograph MAKUSU of the shape of a frame corresponding to the appearance configuration of an up magnetic core is piled up on this resist film 5, and it exposes by predetermined wavelength light.

[0035] Since the antireflection film 4 is formed in the bottom of the above-mentioned resist film 5 at this time, the light

which carried out incidence to the resist film 5, and passed the resist film 5 concerned is absorbed with this antireflection film 4, and reflection is prevented. Therefore, the reflected light turns to the photo-mask bottom, it has not said that an unsuitable field is exposed, and the resist film 5 is exposed faithfully reflecting the configuration of a photo mask. After this exposure, when development is performed, the mask 6 for cores of the shape of a frame corresponding to the appearance configuration of an up magnetic core as shown in drawing 4 will be formed with close dimensional accuracy. In addition, ultraviolet-rays light was used as a light for exposure here.

[0036] And as shown in drawing 5, the antireflection film 4 of the field in which the mask 6 for cores is not formed by performing reactive-ion-etching (O<sub>2</sub>-RIE) processing which used oxygen gas is removed to the whole substrate, and after doing in this way and forming the mask 6 for cores, as shown in drawing 6, the plating substrate film 3 is exposed. Then, as shown in drawing 7, the magnetic films 7, such as nickel-Fe used as an up magnetic core, are deposited with electrolysis plating on with a pH of 2.7 or less conditions on this plating substrate film 3. In addition, it is appropriate for the thickness of this magnetic film 7 to be referred to as about 3-5 micrometers. Then, as shown in drawing 8, the antireflection film 4 which remains in this mask 6 for cores and mask bottom for cores is exfoliated, and an up magnetic core is formed by removing the unnecessary magnetic film which deposits on these remains for cores of a mask, and the outskirts of it, and a plating substrate film by ion etching or wet etching.

[0037] At such a formation production process of an up magnetic core, since it is formed with close dimensional accuracy, without influencing the mask for cores for carrying out patterning of the up magnetic core by the reflected light, close dimensional accuracy is obtained also for an up magnetic core reflecting this. Therefore, even when the width of face near the magnetic-recording data-medium sliding surface of an up magnetic core (truck section) is set up comparatively narrowly, in the thickness direction, this truck section has predetermined width-of-recording-track WT in homogeneity, and will be formed in it.

[0038] Thus, as the nonmagnetic substrate with which two or more formation of the inductive head was carried out is shown in drawing 9, after being cut among drawing in the location of an a-a'line and a b-b'line, being started for every [ 8 ] chip and carrying out a grinding process to \*\* outside predetermined, lead wire is soldered to an end-winding child. And as shown in drawing 10, these head chip 8 is further attached in the suspension device 9, for example, is used as the magnetic head for hard disks. Since the truck section of an up magnetic core is formed by the good truck profile in this magnetic head, it can record by predetermined width-of-recording-track WT to a record medium, and it is possible to raise the recording density in the direction of a truck over a record medium.

[0039] In addition, by the above manufacture method, although the up magnetic core is formed with frame plating, an up magnetic core may be formed by carrying out patterning of this to a desired core configuration, after forming the magnetic film used as the up magnetic core concerned completely.

[0040] That is, after forming a plating substrate film on the 2nd insulator layer in this case, the magnetic film which serves as an up magnetic core the whole surface on this plating substrate film is deposited with electrolysis plating.

[0041] And an antireflection film and a resist film are formed at the same production process as having explained previously on this magnetic film. Subsequently, on this resist film, the photo mask corresponding to the pattern of an up magnetic core is piled up, and it exposes by predetermined wavelength light. Here, when the antireflection film is not formed in the resist film bottom, the light which carried out incidence to exposure reflects by the interface of a resist film and a magnetic film, and un-arranging [ that the unsuitable portion of a resist film exposes by this reflected light ] arises. On the other hand, if the antireflection film is formed in the bottom of this resist film, the light which carried out incidence to the resist film and passed the resist film concerned will be absorbed with this antireflection film, and reflection will be prevented. Therefore, a resist film will be exposed faithfully reflecting the configuration of a photo mask, and the mask for cores corresponding to a core configuration will be formed with close dimensional accuracy.

[0042] And after doing in this way and forming the mask for cores, the antireflection film of the mask circumference for cores is removed by performing reactive-ion-etching processing which used oxygen gas for the whole substrate, and ion etching or wet etching removes a still more unnecessary magnetic film and a plating substrate film. Then, an up magnetic core will be formed by exfoliating the mask for cores, and the antireflection film under it.

[0043] At such a formation production process of an up magnetic core, since it is formed with close dimensional accuracy, without influencing the mask for cores for carrying out patterning of the up magnetic core by the reflected light, close dimensional accuracy is obtained also for an up magnetic core reflecting this. Therefore, even when the width of face near the magnetic-recording data-medium sliding surface of an up magnetic core (truck section) is set up comparatively narrowly, in the thickness direction, this truck section has predetermined width-of-recording-track WT in homogeneity, and will be formed in it.

[0044] Moreover, although the above is the case where this invention is applied to manufacture of an inductive head, this invention may be applied when manufacturing the compound-die magnetic head which uses an inductive head as

the arm head for record, and uses an MR head as the arm head for playback.

[0045] a front end electrode for a compound-die arm head to energize sense current for the lower shield layer which constitutes the MR head section on a nonmagnetic substrate, MR element, and MR element and a back end electrode, and bias -- the conductor which the laminating of a conductor and the up shield magnetic layer is carried out through an insulating material layer in between, and constitutes the inductive head section on this -- a coil layer and an up magnetic core are formed through an insulating material layer in between. In addition, the up shield magnetic layer of an MR head serves also as the function as a lower magnetic core of an inductive head in this case.

[0046] It faces forming the up magnetic core of such a compound-die arm head, and if the antireflection film is formed before forming the resist film used as the mask for cores, it will be exposed without influencing a resist film of the reflected light, and the mask for cores will be formed with close dimensional accuracy. Therefore, reflecting this, close dimensional accuracy is obtained, the truck section has predetermined width-of-recording-track WT in homogeneity in the thickness direction, and an up magnetic core will also be formed.

[0047]

[Effect of the Invention] By the manufacture method of the thin film magnetic head of this invention, since the antireflection film is formed and a resist film is formed on this antireflection film before forming the resist film used as the mask for cores, it is exposed without influencing a resist film of the reflected light, and the mask for cores is formed with close dimensional accuracy, so that clearly also from the above explanation. Therefore, reflecting this, close dimensional accuracy is obtained, for example, the truck section has predetermined width-of-recording-track WT in homogeneity in the thickness direction, and an up magnetic core is also formed. Thus, since side fringing is stopped small, the manufactured magnetic head is recordable with the predetermined width of recording track to a record medium, and can raise the recording density in the direction of a truck. Moreover, it can contribute also to the improvement in the yield of the thin film magnetic head.

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[Translation done.]

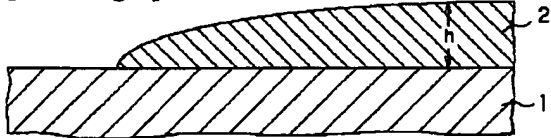
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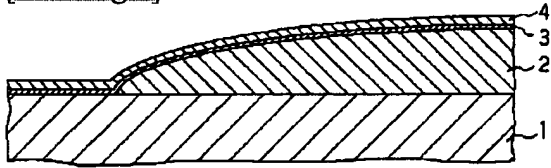
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## DRAWINGS

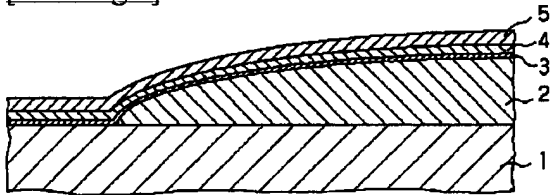
[Drawing 1]



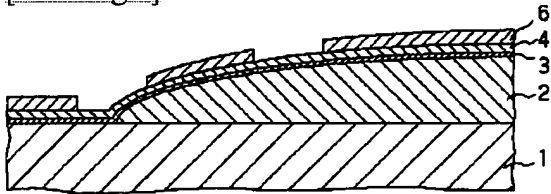
[Drawing 2]



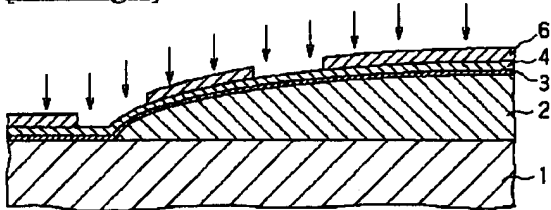
[Drawing 3]



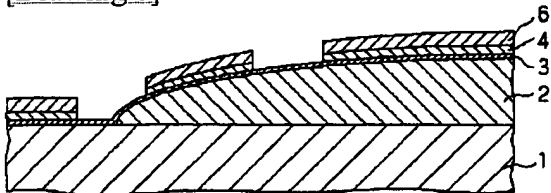
[Drawing 4]



[Drawing 5]

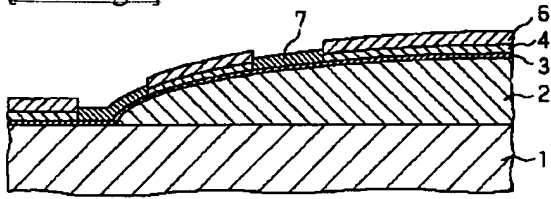


[Drawing 6]

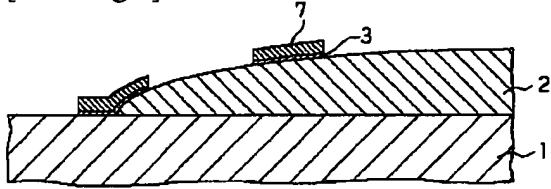




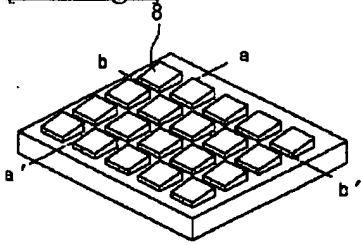
[Drawing 7]



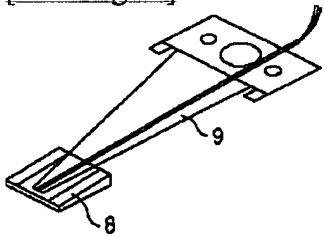
[Drawing 8]



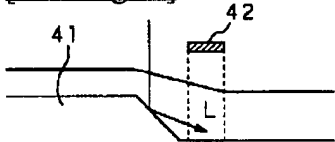
[Drawing 9]



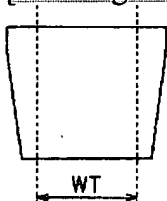
[Drawing 10]



[Drawing 13]

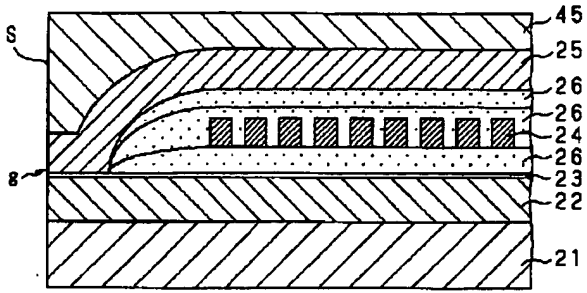


[Drawing 15]



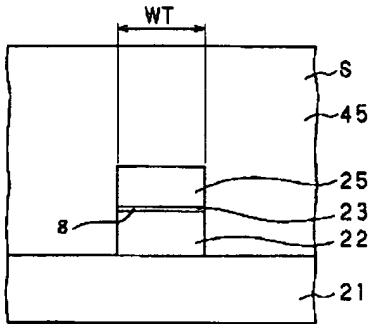
[Drawing 11]

(a)



インダクティブヘッドの断面図

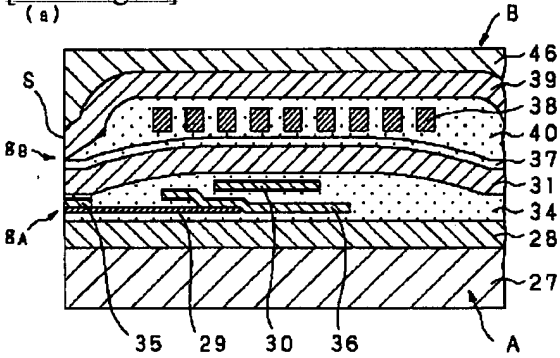
(b)



インダクティブヘッドの正面図

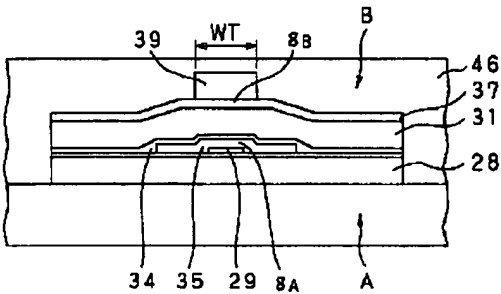
[Drawing 12]

(a)



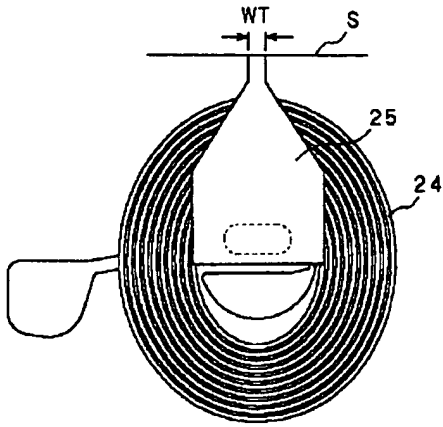
複合型薄膜磁気ヘッドの断面図

(b)



複合型薄膜磁気ヘッドの正面図

[Drawing 14]



上部磁気コアの平面図

[Translation done.]